Designing a Thermal Energy Storage system to utilise seasonal variations in renewable electricity generation to meet seasonal variations in heat demand

Designing a Thermal Energy Storage system to utilise seasonal variations in renewable electricity generation to meet seasonal variations in heat demand

Daniel Friedrich

Institute for Energy Systems, School of Engineering, The University of Edinburgh, The King's Buildings, Mayfield Road, Edinburgh, EH9 3JL, UK

d.friedrich@ed.ac.uk

Balancing the seasonal variation in demand is one of the largest challenges in the decarbonisation of the energy system. For example, in the UK the natural gas demand increases from around 1.5 TWh per day in summer to more than 3.0 TWh per day in winter. This variation is to a large extent due to the increased heating demand and here specifically due to the domestic heating demand. Currently the demand fluctuations can be balanced due to the dispatchable nature of fossil fuel based electricity and heat generation. However, with the increase of non-dispatchable renewables in the energy mix, different solutions are needed. One solution to balance the seasonal variation is seasonal energy storage. Several options ranging from thermal aquifer storage to power-to-fuel systems with liquid fuel storage have been proposed. However, all of these methods are rather expensive or suffer from low efficiencies. Furthermore, the required storage capacity for the UK would be more than 100 TWh. A second option is the utilisation of seasonal variations in renewable energy generation with short to medium term storage.

In this contribution we are investigating the use of seasonal variations in wind generated electricity to cover the variations in domestic heating demand. Wind and wave electricity generation in the UK have a similar trend to the demand albeit with large short term variations. We have linked the heat generated from the variable wind electricity supply, i.e. by a water source heat pump, to the heat demand (space heating and hot water) of an ensemble of buildings in a district heating network. By using analytical and optimisation methods we have designed a hybrid Thermal Energy Storage system which reliably matches the thermal demand from the variable wind electricity supply. This system combines short term storage in the individual dwellings and medium term storage at the district heating plant.

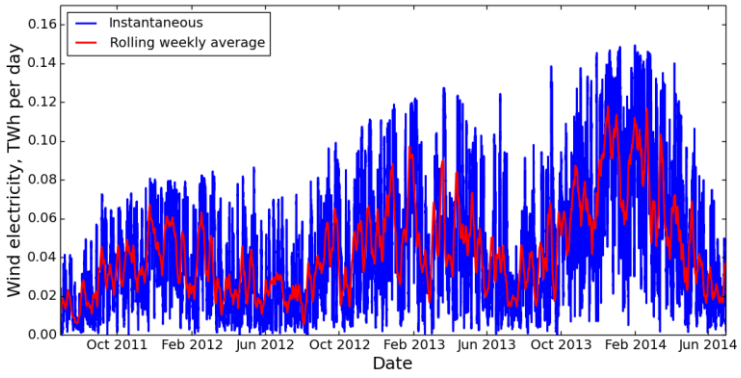

Figure 1: Variable wind energy in the UK grid. Data adapted from National Grid.